MESSER
Gases for Life

MESSER HYDROGEN

DIRK DE KEULENAER

FAIP VZW 20/02/2025

Messer Group History

WE ARE
MADE
BY HISTORY.

Messer is…

Company

Founded in 1898, Messer is today the world‘s largest family-run industrial gases specialist, present in key markets of Europe, Asia and the Americas.

Products

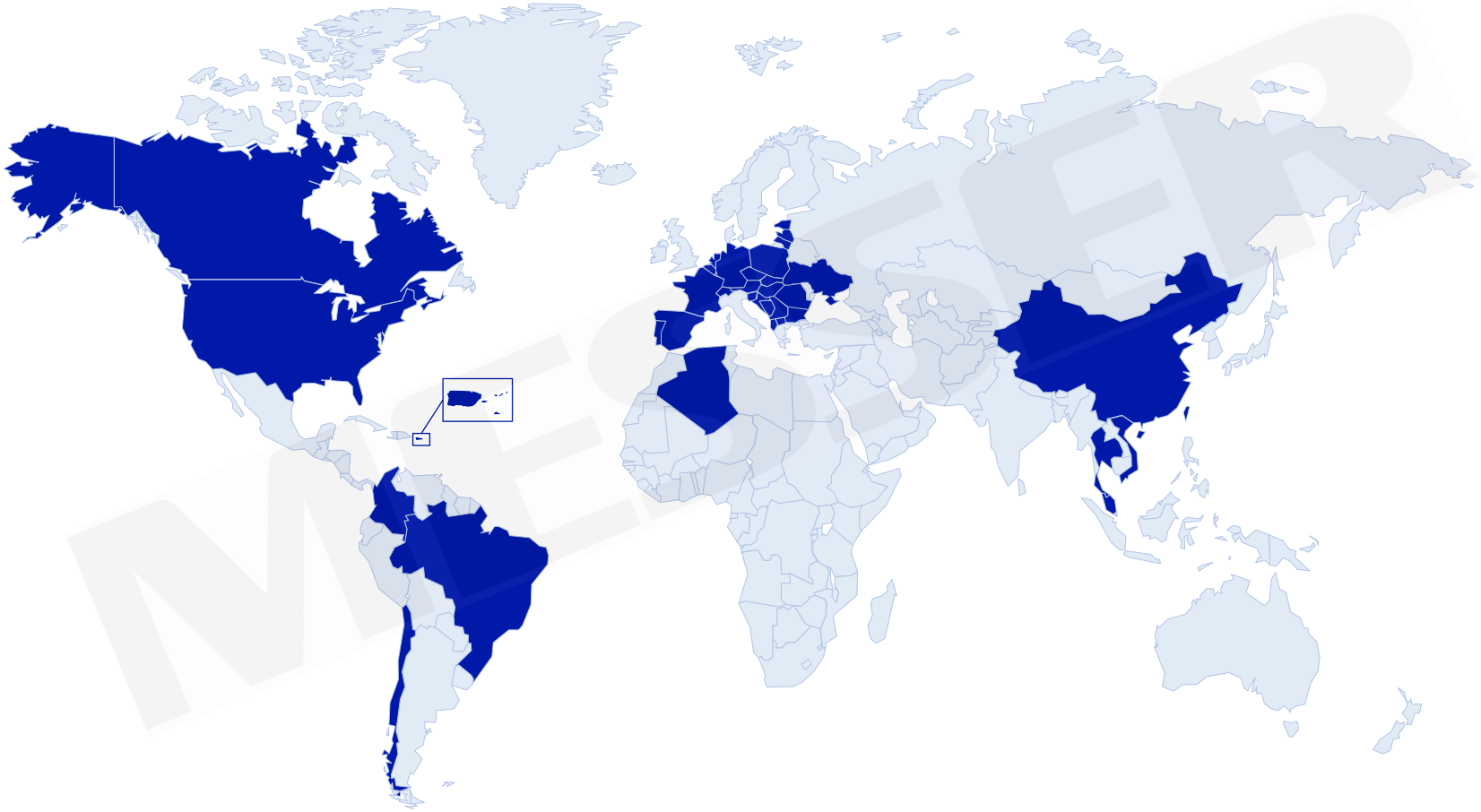
Messer manufactures and supplies oxygen, nitrogen, argon, carbon dioxide, helium, **hydrogen**, shielding gases for welding, specialty gases, medical gases and food gases as well as many different gas mixtures.

Customers

Almost all industrial sectors, healthcare as well as science and research benefit from our products and application technologies.

Successful in Asia, Europe and the Americas

MESSER
Gases for Life



Sales and number of employees 2023

		Total*
Sales	in billion euro	4.4
Investments	in million. euro incl. IFRIC4	636
Employees	Contractual employment relationships in FTE**	11,519

* Consolidated presentation of Messer (formerly Messer Group and Messer Industries), which includes the former 100 percent equity-accounted investment in Messer Industries and was adjusted for the effects of the acquisition of Messer Industries in November 2023.

** Full Time Equivalent

The right solution for every application

Reliable
for smaller jobs

- ✓ Cylinders or cylinder bundles
- ✓ Local distribution partners or directly from the filling plant

Effective
for medium-sized jobs

- ✓ Storage tank on-site with gas supply from a road tanker

Optimal
for large jobs

- ✓ Gas production at the customer’s site
- ✓ Hydrogen and synthesis gas production facilities

Perfect
for the biggest jobs of all

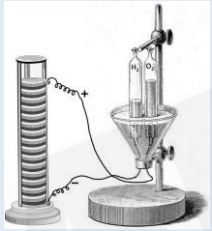
- ✓ Pipeline systems with a direct connection to the business park or bulk consumer

Hydrogen – a bit of history

1671 Robert Boyle, experimenting with metals by dipping them in acid thus producing H2 gas

1776 Hydrogen was first **identified as a distinct element** by Henry Cavendish

1788 Antoine Lavoisier gave hydrogen its name, which was derived from the Greek words **“hydro”** and **“genes,”** meaning “water” and “maker”



1800 First electrolysis William Nicholson and Anthony Carlisle discovered that applying electric current to water produced H2 and O2 gases.

1838 The **fuel cell effect**, combining H2 and O2 to produce water and an electric current, was discovered by Christian Schoenbein

1860 Etienne Lenoir invented the 1-cylinder, 2-stroke **Hippomobile** : hydrogen was fed in a small horizontal combustion engine.

1874 Jules Verne, prophetically examined the potential **use of hydrogen as a fuel** in his popular work of fiction entitled *The Mysterious Island*.

1920 Rudolf Erren, a German engineer, **converted internal combustion engines** of trucks, buses, and submarines to use hydrogen or hydrogen mixtures

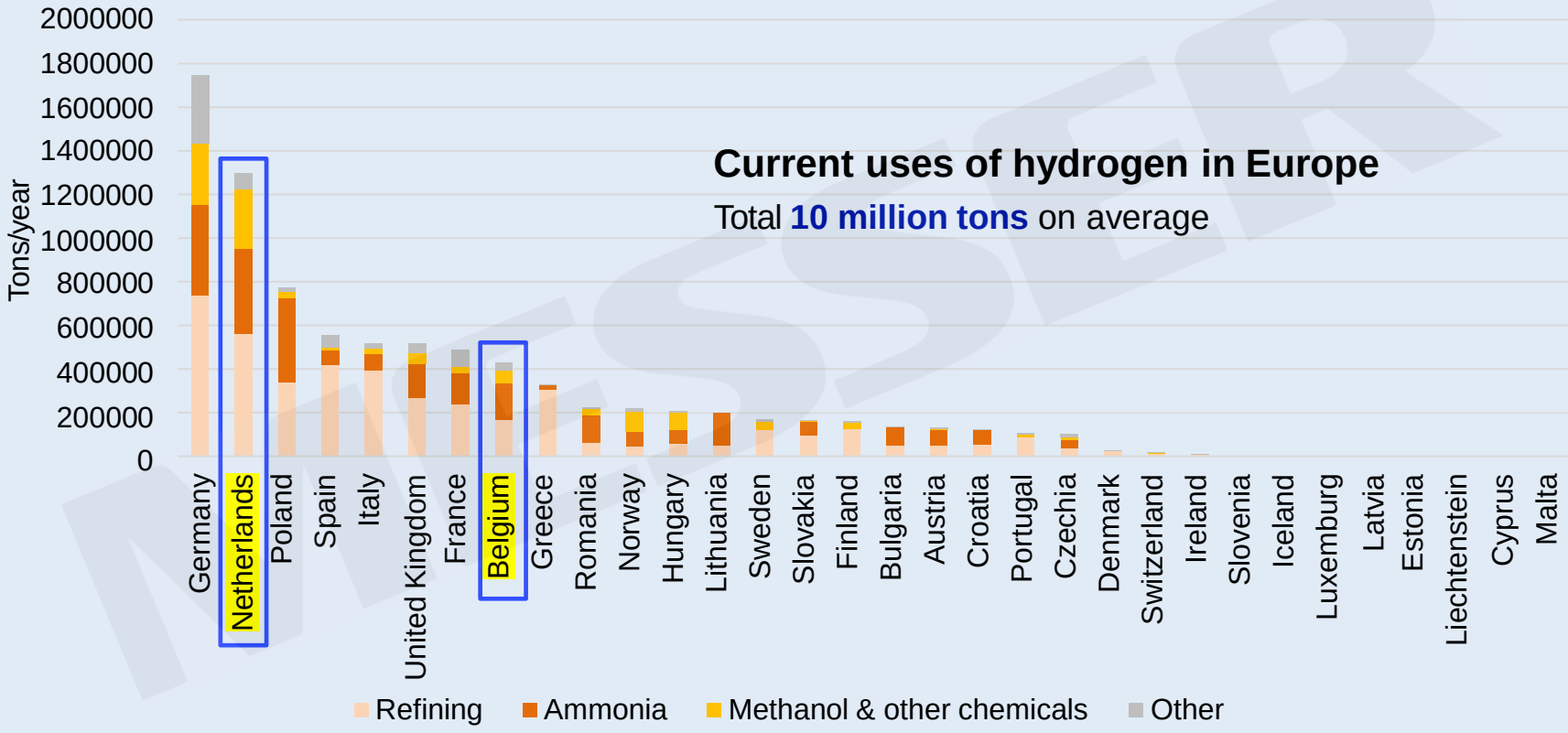
1937 The **Hindenburg** disaster

1958 NASA use of liquid H2 for rocket propulsion

1960... Significant development of **H2 in (petro-) chemical industries** and beyond

1970 Term **“Hydrogen economy”** by Prof. John Bockris at General Motors Technical Center

Hydrogen market overview

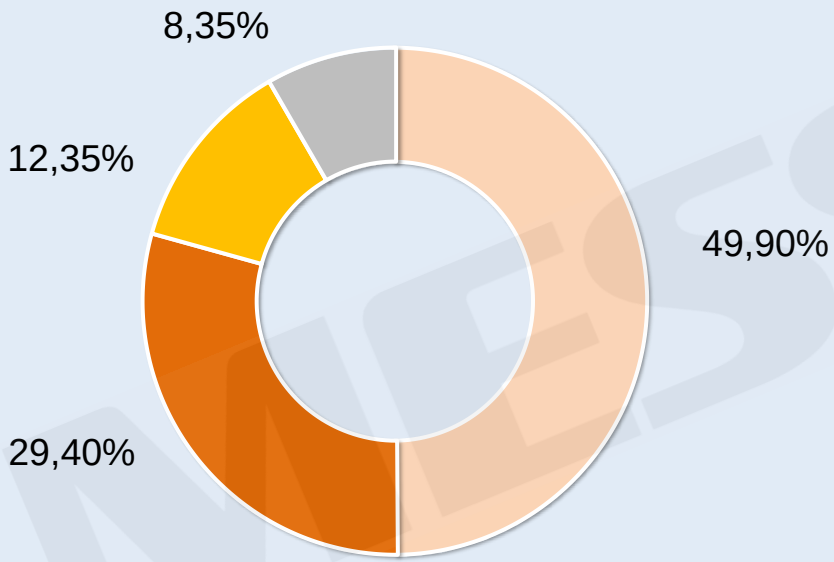


Source: Hydrogen Europe, updated March 2022.

Hydrogen market overview

Current uses of hydrogen in Europe

Total 10 million tons on average



Refining
Hydrocracking - Hydrotreatment

Ammonia
Production process involves a synthesis of hydrogen with nitrogen.

Methanol & other chemicals
Cyclohexane, aniline, caprolactam, oxo alcohols, toluene diisocyanate (TDI), hexamethylenediamine, adipic acid, hydrochlori,...

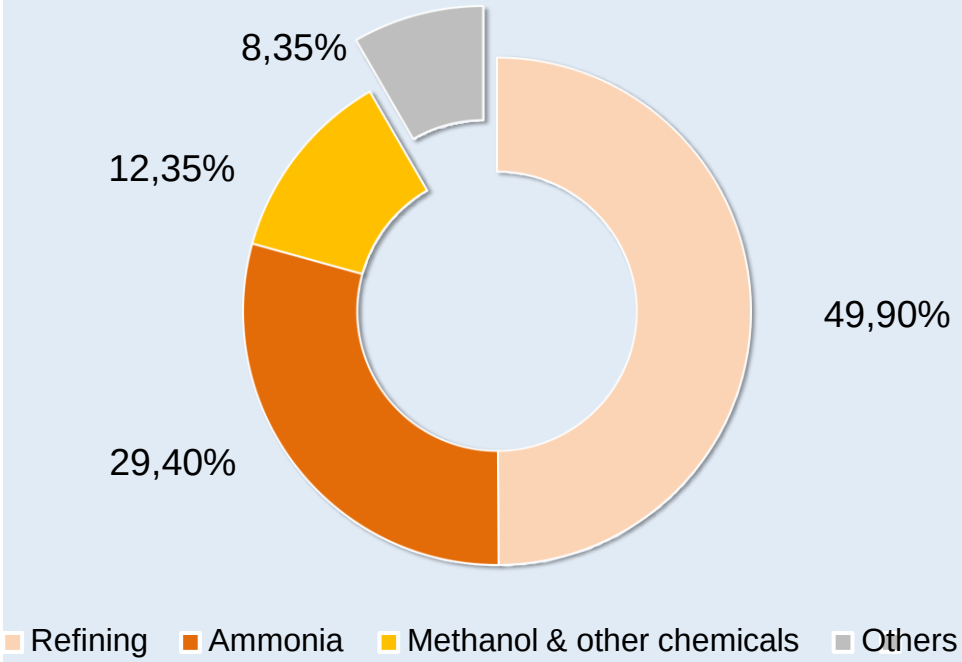
Others

Source: Hydrogen Europe, updated March 2022.

Hydrogen market overview

Current uses of hydrogen in Europe

Total 10 million tons on average



Others

- In **food processing**, hydrogenation of fatty acids from vegetable oils
- In **semiconductor market**, hydrogen is used as reducing and etching agent
- In **glass manufacturing,** as protective gas to prevent oxidation of the glass surfaces
- **I**n **annealing furnaces,** a mixture of hydrogen and nitrogen is used
- In **mobility** : heavy duty trucks, buses, forklifts, terminal tractors, trains, boats
- As **alternative fuel,** as energy carrier
- **Storage** as alternative feedstock (vs batteries)
- Injection of **natural gas grid**
- …

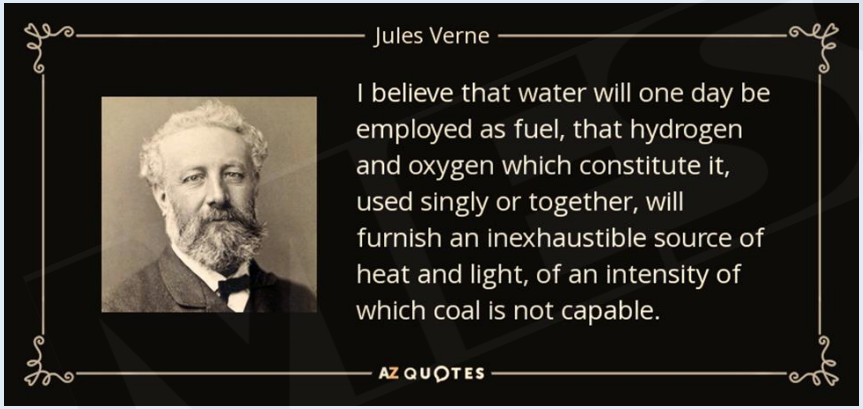
Source: Hydrogen Europe, updated March 2022.

Hydrogen market overview

Current uses of hydrogen in Europe

Total 10 million tons on average

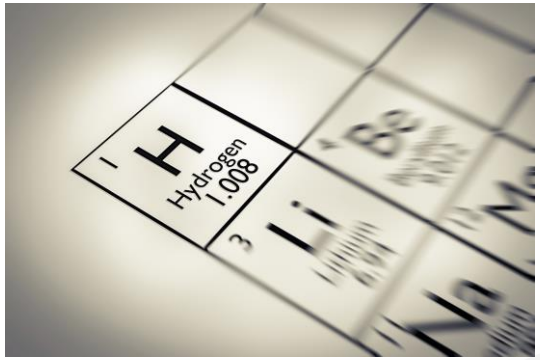
1874...

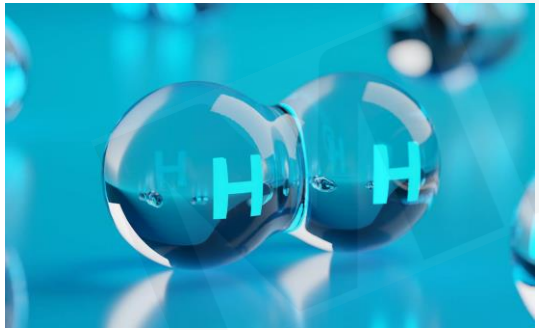


Others

- In **food processing**, hydrogenation of fatty acids from vegetable oils
- In **semiconductor market**, hydrogen is used as reducing and etching agent
- In **glass manufacturing,** as protective gas to prevent oxidation of the glass surfaces
- In **annealing furnaces,** a mixture of hydrogen and nitrogen is used
- As **alternative fuel,** as energy carrier
- In **mobility** : heavy duty trucks, buses, forklifts, terminal tractors, trains, boats
- **Storage** as alternative feedstock (vs batteries)
- Injection of **natural gas grid**
- …

Hydrogen – basics & properties

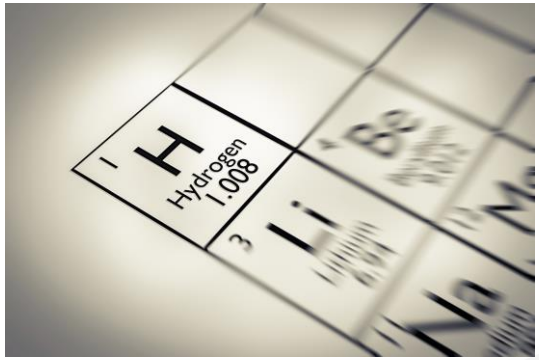


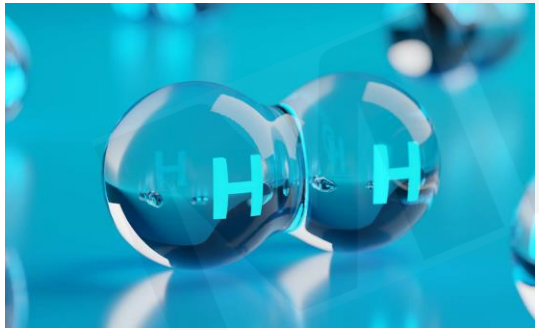


- First and top-left member of the periodic table of elements : it's the **lightest atom of all**.
- **Most abundant chemical element** on our planet (water, hydrocarbons, etc.), but scarce under molecular form.
- Molecular **hydrogen gas, or H_2**, is the primary form in which hydrogen is found. The hydrogen molecule contains two protons and two electrons making it a neutrally-charged molecule.

- **Colourless, odourless, tasteless**, non-metallic highly **flammable** gas. Burns with a pale blue, almost invisible flame.
- **Nontoxic**, but can cause asphyxiation by displacing oxygen in the air.

Hydrogen – basics & properties





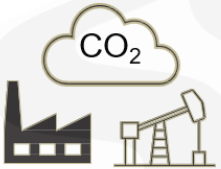
Characteristic	Hydrogen	Commentary
Density gaseous phase (0 °C, 1 atm)	0,090 kg/Nm^3	14 times lighter than air
Density liquid phase (-253 °C, 1 atm)	70,79 g/l	6 times lighter than LNG
Boiling point (1 atm)	-252,76 °C	LNG -161 °C
Energy density per unit of mass (LHV)	120,1 MJ/kg	3x that of gasoline, 2,5x that of natural gas
Energy density ambient cond. (LHV)	10,8 MJ/Nm^3	1/3 of natural gas
Energy density liquid (LHV)	8,5 MJ/l	1/3 of LNG
Flammability limits in air (25 °C, 1 am)	4 - 75 vol%	methane: 5,3 – 15,0 vol%
Detonation limits in air (25 °C, 1 atm)	15 - 59 vol%	methane: 6,3 - 13,5 vol%
Auto-ignition temperature	585 °C	methane: 540 °C
Ignition energy	0,02 mJ	methane: 0,29 mJ

Notes : LHV – lower heat value

Hydrogen production

96,0%

GREY HYDROGEN



Hydrocarbons

Pros

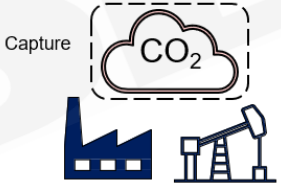
Mature technology
Generally low levelized cost if NG is cheap

Cons

Non-renewable
High carbon emissions

0,4%

BLUE HYDROGEN



Hydrocarbons

Pros

Existing SMR installations can be retrofitted
Capture of up to 90% carbon emissions

Cons

High costs
Social and Governmental acceptance

3,6%

GREEN HYDROGEN

H_2O and renewable energy

Pros

Renewable
No carbon emissions

Cons

High capital costs
Low amount of renewable energy available

Hydrogen production - grey

SMR – Steam Methane Reforming

ATR – Auto Thermal Reaction

POX – Partial Oxidation

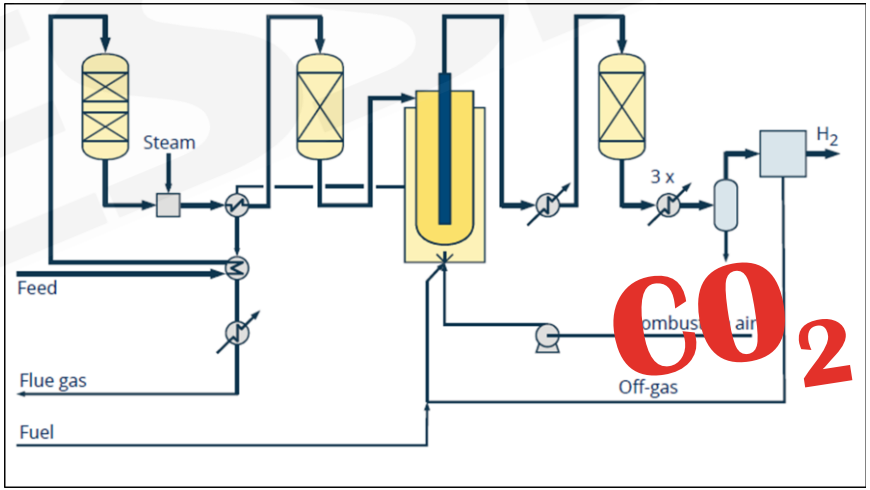
Coal – Coal gasification

$CH_4 + H_2O$ (+ heat) → $CO + 3\ H_2$

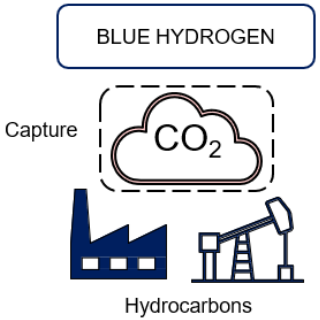
Water-gas shift reaction :

$CO + H_2O \rightarrow \mathbf{CO_2} + H_2$ (+heat)

1 t H_2 ≈ 10 t CO_2



Hydrogen production – blue



Pros

Existing SMR installations can be retrofitted

Capture of up to 90% carbon emissions

Cons

High costs

Social and Governmental acceptance

Blue hydrogen

Blue hydrogen is basically grey hydrogen. However, CO_2 is captured during production and permanently stored in geological formations (CCS) or used in other applications (CCU). Since the CO_2 is not released into the atmosphere, the production of blue hydrogen is considered CO_2-neutral.

CCS
Carbon Capture and Storage

- Depleted oil and gas reservoirs
- Deep underground formations capped off with impermeable rock
- Possible underground deposits where it gradually combines with existing minerals.

CCU
Carbon Capture and Use

- Utilization of CO_2
- In cement, polymers, carbon fibers, animal feed, etc.
- Production of alternative fuels
- Utilisation paths are limited in size.

Hydrogen production – green

GREEN HYDROGEN

H_2O and renewable energy

Pros
Renewable
No carbon emissions

Cons
High capital costs
Low amount of renewable energy available

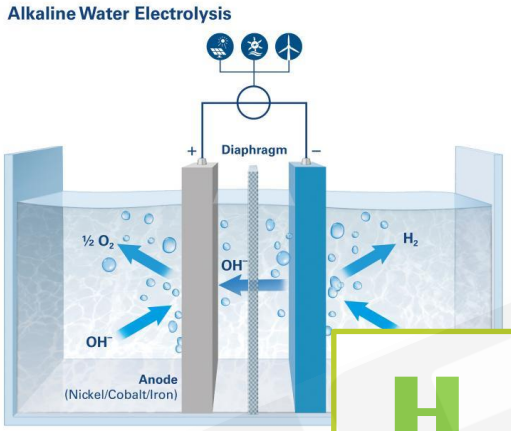
Green hydrogen

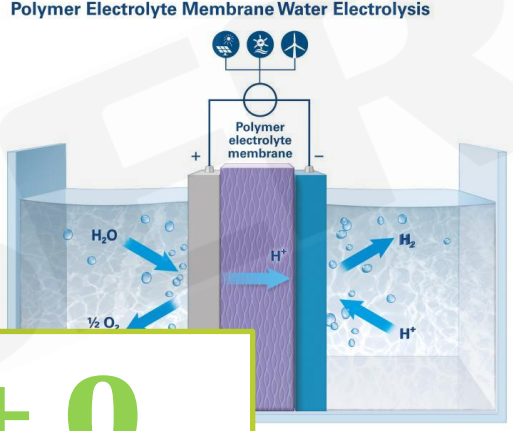
Also called renewable hydrogen, is produced by electrolysis of water

An electric current is passed through water. This electrical energy causes water molecules to break down into hydrogen ions (H+) at the cathode and hydroxide ions (OH-) at the anode, ultimately producing hydrogen gas (H_2) and oxygen gas (O_2) at their respective electrodes.

The electricity required for this must come exclusively from renewable energy sources (wind, photovoltaic, hydropower) . This makes its production CO_2-neutral.

Hydrogen production – green





$$H_2O \rightarrow H_2 + O_2$$

- 2 electrodes immersed in a liquid … solution ~30%)
- Separated by a diaphragm (e.g. Zirfon) that provides for the transport of hydroxide ions between the anode and the cathode.
- Operating temperatures up to 80ºC. Poor efficiency at high current density, large cells are needed.

… direct contact with the membrane

- Operates at lower temperatures up to 70ºC and high pressures (up to 45 bar). Hydrogen protons travel through a polymer membrane to the cathode.
- High material cost but better efficiency at high current density. Fast load changes possible.

In the 1980’s

We were ahead of our time …

Electrolysis

Messer was partner in a 55 Mio. DM project to produce 120 Nm^3/day H2 using a 350 kW solar cell in Riad, Saudi Arabia

Mobility

Messer developed liquid hydrogen refueling systems together with BMW

Der Kryo-Tank mit flüssigem Wasserstoff hinter den Rücksitzen im Kofferraum des BMW 735il. Der Ventilblock (Magnet- und Rückschlagventile) ist außerhalb des Tanks angeordnet, um das Eindringen von Wärme in den Tank zu minimieren. Der Wasserstoff gelangt über den Ventilblock und durch eine doppelwandig vakuumisolierte Leitung am Fahrzeugunterboden zum Motor. (Foto: BMW, 1989)

Today

Emissions-free logistics processes

Since 2004, Messer has been the technology and hydrogen supplier for one of the largest fleets of forklift trucks and other industrial handling equipment in the USA.

Emissions-free inner cities

Since 2011, Messer has been the technology and hydrogen supplier for one of the largest fleets of fuel cell-powered electric buses (FCEBs) in the USA.

Today

Purities up to 6.0 and 300 bar technology

A cryogenic post-purification system at the filling plant in Antwerp eliminates unwanted impurities in hydrogen gas such as oxygen, moisture and hydrocarbons.

The hydrogen quality is thus increased up to 6.0 (> 99,99990%), subsequently, hydrogen is filled in cylinders and bundles at 200 or 300 bar.

Supply by trailer

Messer transports hydrogen over the road using trailers equipped with the latest technology and safety measures, operating at pressures up to 380 bar.

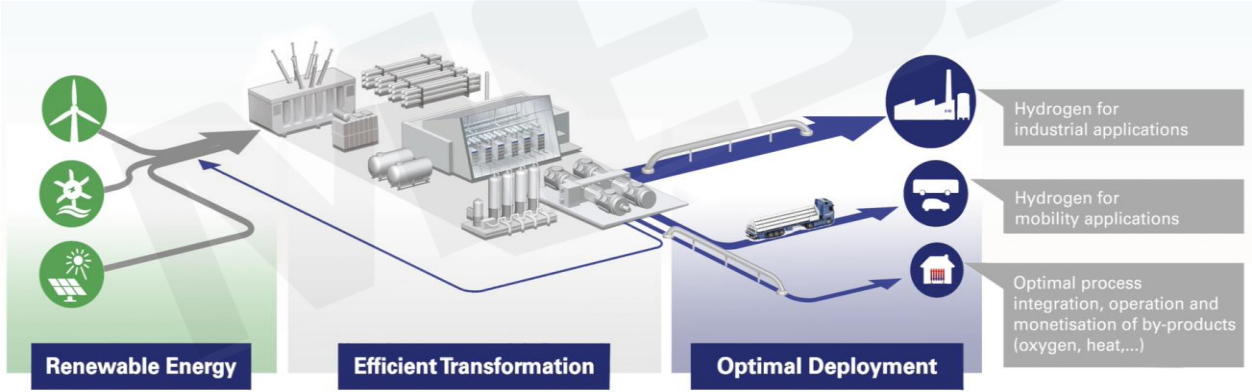
Hydrogen capacities range from 450 to 1150 kg.

Today – H2 onsite concept

H2 Onsite concept - optimal generation and use of green hydrogen

Optimal generation for hydrogen production in industrial applications such as petrochemicals, chemicals, food and steel, as well as in mobility applications.

Planning, financing, construction and operation of electrolysis-based hydrogen production plants by Messer, in line with the the "Build Own Operate" (BOO) business model



Today – Genset concept

Hydrogen for hydrogen-powered gensets

Messer offers hydrogen for dual-fuel, ICE or FC gensets via large capacity bundles (300 bar, F50*18, 19,1 kg/bundle).

A connection skid allows for easy, plug-and-play connection of hydrogen bundles to generator sets. This setup simplifies the process, making it quick and efficient to link hydrogen supply systems to the gensets, ensuring smooth operation with minimal technical complexity.

Today – “SympH2ony”, a One-Stop-Shop concept

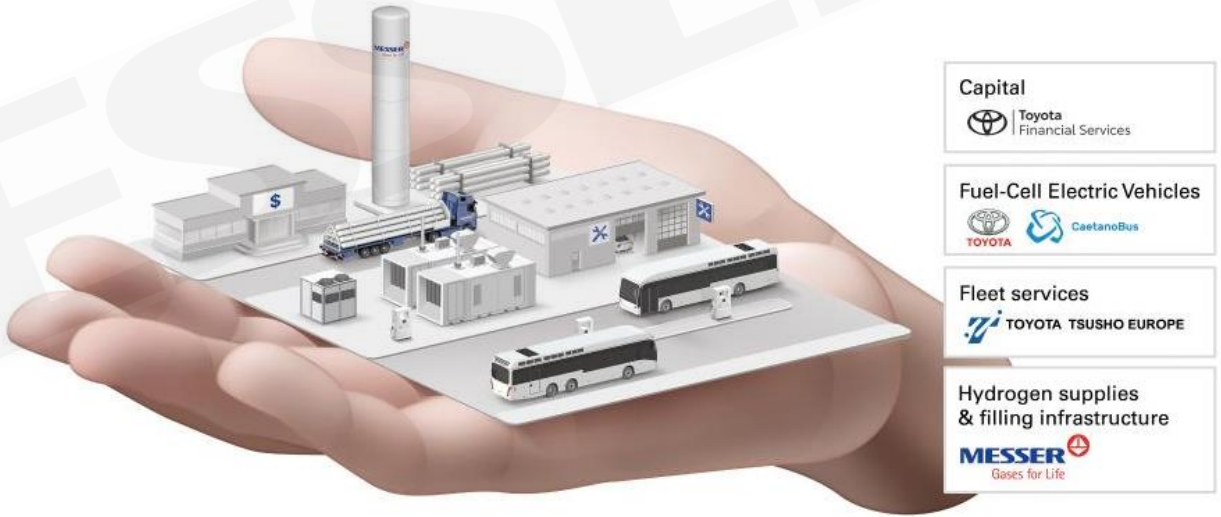
One-Stop-Shop

“SympH2ony” stands for hydrogen mobility solutions for the complete fleet operation chain. It offers companies, cities, municipalities and port operators in Europe a comprehensive solution for hydrogen-powered vehicle fleets - including hydrogen supply, infrastructure and all services required for operation: the "One-Stop-Shop

- Predictable TCO through payment per kilometer driven, per kilogram of hydrogen consumed or per CO2e emission reduction
- Fleet operator can concentrate on core business

SympH2ony

https://www.symph2ony.eu



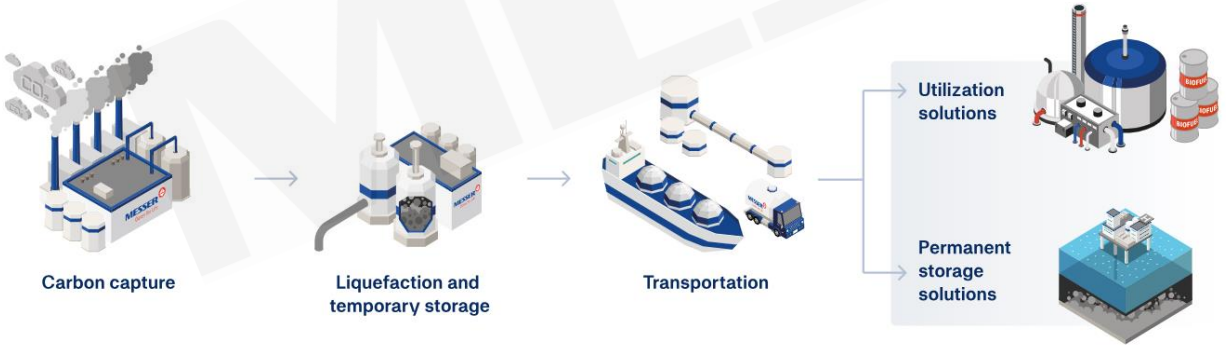
Today – ZeCarb concept

Carbon Capture as a Service (CCaaS)

ZeCarb stands for "zero carbon". ZeCarb is committed to capture CO2 emissions and achieve ambitious climate goals, while generating new opportunities for business.

Messer is an experienced and trusted Carbon Capture, Utilization and Storage (CCUS) partner. We offer innovative and high-quality solutions for companies to achieve their net zero goals.

See : [Home - ZECARB (messergroup.com)]



Today – Hydrogen safety

General properties and precautions

- Highly flammable - wide flammability range (4%-75% in air).
- Colorless and odorless: Leaks are difficult to detect without special sensors.
- Light gas: Hydrogen rises quickly, aiding ventilation but also causing accumulation under ceilings.
- Low energy density per volume: Hydrogen must be stored under high pressure or at extremely low temperatures as a liquid.

Cover the safe production, handling, storage and use of hydrogen

- Inerting and purging
- Ventilation and flaring
- Leak and flame detection systems
- Ignition source management
- H2 sensors, UV/IR detectors
- Grounding, anti static devices, ATEX zoning
- Automatic shut off valves
- Certified pressure tanks and control systems
- Mechanical integrity, reactive chemistry
- Facility spacing
- Human factor – Safety training !

Today – Hydrogen safety

H2safety.info is a global web-platform centralising hydrogen safety standards and publications for easy access

EIGA is convinced the only good roll-out is a safe rollout. How pity would it be if avoidable accidents were to happen, potentially impacting the very hydrogen rollout itself.

1

Production

Electrolysis

Chemical byproduct

Steam methane reforming

Carbon capture

2

Conditioning

Compression

Liquefaction

3

Storage

Industrial storage

Mass storage

4

Transport

Pipeline

Cylinders

Bulk transport (gas)

Bulk transport (liquid)

5

Applications

Feedstock industry

Fuel for transport

Heating

Today – Why today ?

EU Science Hub

Home > JRC news and updates > Global drought threatens food supplies and energy production

NEWS ANNOUNCEMENT | 2 October 2024 | Joint Research Centre | 3 min read

Global drought threatens food supplies and energy production

Record temperatures and low rainfall have had impacts on food security, livelihoods, and energy production in many world regions.

Drought in Ethiopia has resulted in several livestock losses
© European Union, 2022 (photographer: Silvya Bolliger)

In July 2024, global temperatures reached unprecedented levels, breaking historical records with an average of 17.16 °C. This extreme heat led soil water to evaporate, leaving the vegetation and biodiversity more fragile and under stress in many regions of the world. This, combined with unusually low rain levels, caused major river basins like the Amazon, La Plata, and Zambezi to have lower-than-normal water flows, impacting economies and the broader ecosystems they are part of.

Global drought threatens food supplies and energy production - European Commission (europa.eu)

DE TIJD

Nieuws Beleggen LIVE Mijn Geld Sabato ABONNEER NU LOG IN

Kans op 'no landing'-scenario Amerikaanse economie stijgt, vastgoedaandelen grootste slachtoffer

Wordt Arkansas het nieuwe lithiummekka?

Verzekeraar AG trekt zich terug uit winkelverhuurder Ascencio

Zwaarste bosbranden in decennia: na rampjaar 2023 is ook 2024 extreem verwoestend

©REUTERS

LAURENS DEKOCK, THOMAS ROELENS
29 augustus 2024 19:07

Na het recordjaar 2023 wordt de wereld opnieuw geconfronteerd met uitzonderlijk zware bosbranden. Daar is de mens zelf de oorzaak van. 'Koolstofkredieten zijn geen goede oplossing', zegt een expert. 'We moeten onze uitstoot terugdringen en bestaande bossen beschermen.'

Zwaarste bosbranden in decennia: na rampjaar 2023 is ook 2024 extreem verwoestend | De Tijd

vrt nws

Buitenland Europa

Een bus probeert door de watermassa te rijden in Catania.

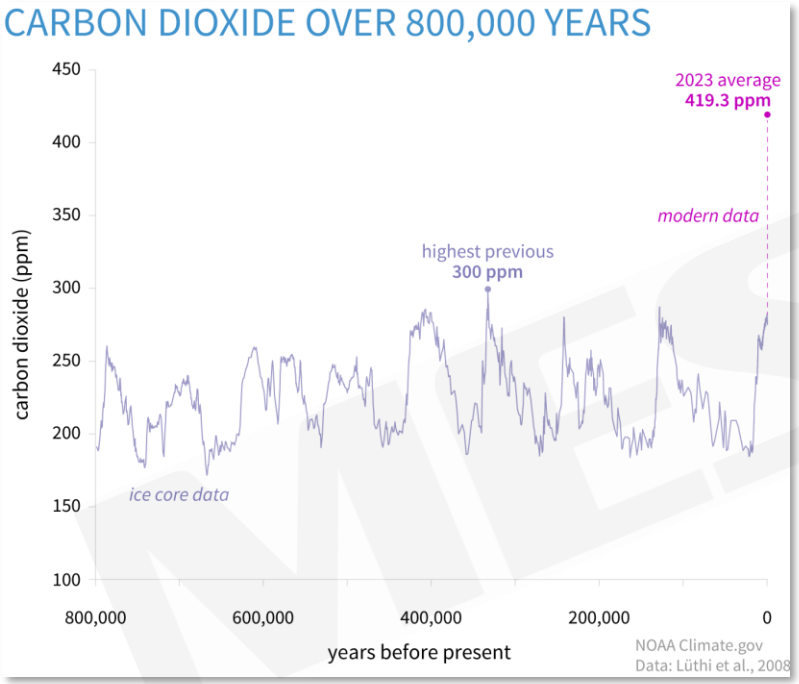
Straten veranderen in rivieren na hevige regenval op Italiaanse eiland Sicilië

Na Frankrijk wordt ook Italië getroffen door intense neerslag. In veel regio's regent het al 2 dagen vrijwel onafgebroken. Ook het eiland Sicilië is getroffen. Na een periode van maandenlange droogte lijken verschillende straten daar nu veranderd in rivieren.

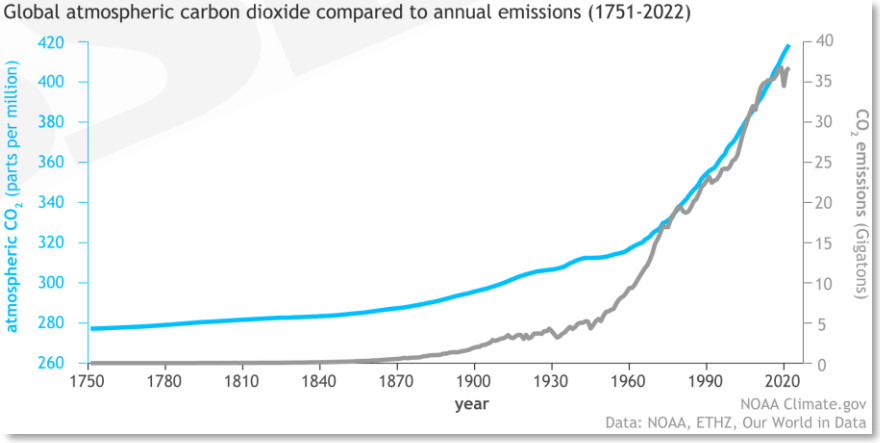
Sara Van Poucke

Straten veranderen in rivieren na hevige regenval op Italiaanse eiland Sicilië | VRT NWS: nieuws

Today – Why today ?



Latest	
Date	Reading
Feb. 19, 2025	426.99 ppm



Today – EU ambitions

2008

EUROPEAN CLIMATE PACKAGE

- - 20% CO2 emissions
- + 20% Renewable Energy
- + 20% Efficiency
- + ETS

2009

RENEWABLE ENERGY DIRECTIVE I (RED I)

- Binding target 20% RE by 2020

2014

2030 CLIMATE AND ENERGY FRAMEWORK

- - 40% CO2 by 2030
- + 32% RE
- + 32,5% Eff.

2018

RENEWABLE ENERGY DIRECTIVE II (RED II)

- Binding target 32% RE by 2030
- Criteria for biofuels

2019

EUROPEAN GREEN DEAL

- Net zero greenhouse gas emissions by 2050
- Circular economy
- Biodiversity & sustainable agriculture

2021

FIT FOR 55

- -55% CO2 by 2030
- Strengthens ETS system

2022

REPOWER EU

- Response to energy crisis – accelerate RE transition
- Promote energy savings & efficiency

2023

RENEWABLE ENERGY DIRECTIVE III (RED III)

- Proposed target 45% RE by 2030
- 42,5% binding, +2,5% optional

Today – Why today ?

RENEWABLE ENERGY DIRECTIVE III (RED III)

"The latest calculations suggest that the implementation of the Green Deal will result in about 3mn-6mn t/yr renewable hydrogen by 2030," according to notes prepared for the EU's designated energy commissioner, Dan Jorgensen, for a European Parliament hearing.

The Green Deal includes several regulations intended to stimulate renewable hydrogen demand in industry and transport, including the revised renewable energy directive (RED III) and ReFuelEU aviation and FuelEU maritime initiatives.

Industry

In the industry sector, Red III requires a 1.6% annual increase in renewable energy usage.

Member States must ensure that **at least 42% of hydrogen used for energy and non-energy purposes in the industry** comes from non-biological origin by 2030, and 60% by 2035.

…t have …he final …e gas …% by 2030.

…dary target : Member states are required to **increase the share of RFNBOs (mainly renewable hydrogen and synthetic hydrogen fuels)** to at least 1%. RFNBO's also contribute toward a combined target of 5,5% RFNBO's and advances biofuels (generally derived from non-food feedstocks).

Today – HyOffwind green hydrogen

Messer, Virya Energy and HyoffGreen have started the construction of first renewable H2 plant in Zeebrugge

JULY 2024
FINAL INVESTMENT DECISION

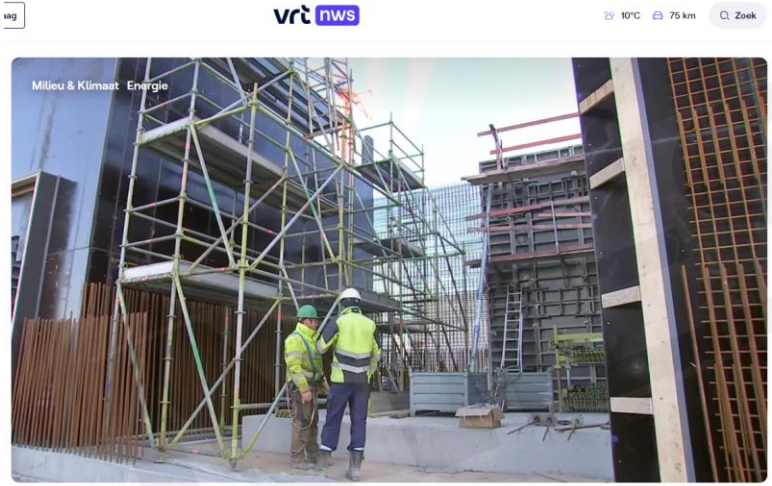
AUGUST 2024
CONSTRUCTION START

Q3 2026
COMMISSIONING

Q4 2026
GO LIVE

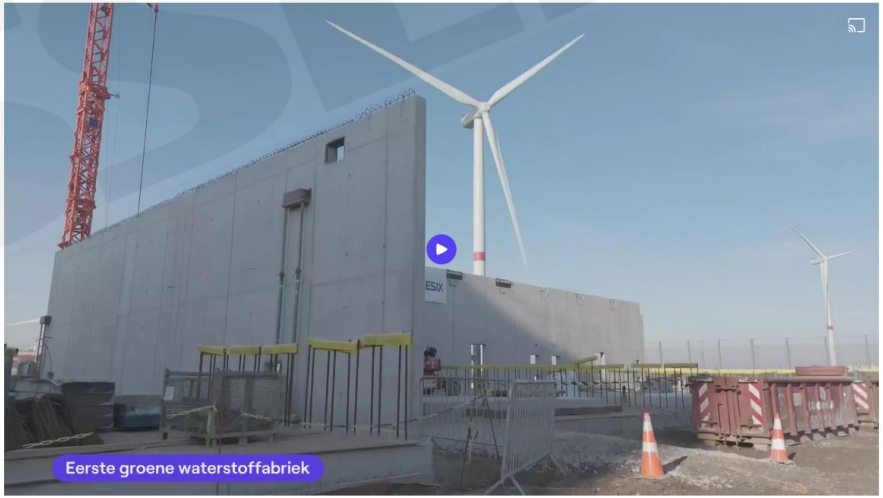
VRT nieuws – 17 februari 2025

https://www.vrt.be/vrtnws/nl/2025/02/17/bouw-gestart-aan-eerste-fabriek-voor-groene-waterstof-in-belgie/



De energiefabriek van de toekomst? Eerste Belgische centrale voor "groene waterstof" wordt gebouwd in Zeebrugge

Bekijk: Vervoer van groene waterstof is geen probleem en er zijn ook afnemers voor



Today – HyOffwind green hydrogen

Basic specifications

25 MWe capacity – pressurized alkaline

<u>As from Q4 2026</u>

3.700 ton or 148 GWh H_2 / year
RFNBO certified
25.000 ton CO_2 reduction / year
Transport H_2 via road 380 bar
Fuel cell grade ISO14687

Expandable to 37 MWe - 100 MWe
To be connected to Fluxys H2 Backbone

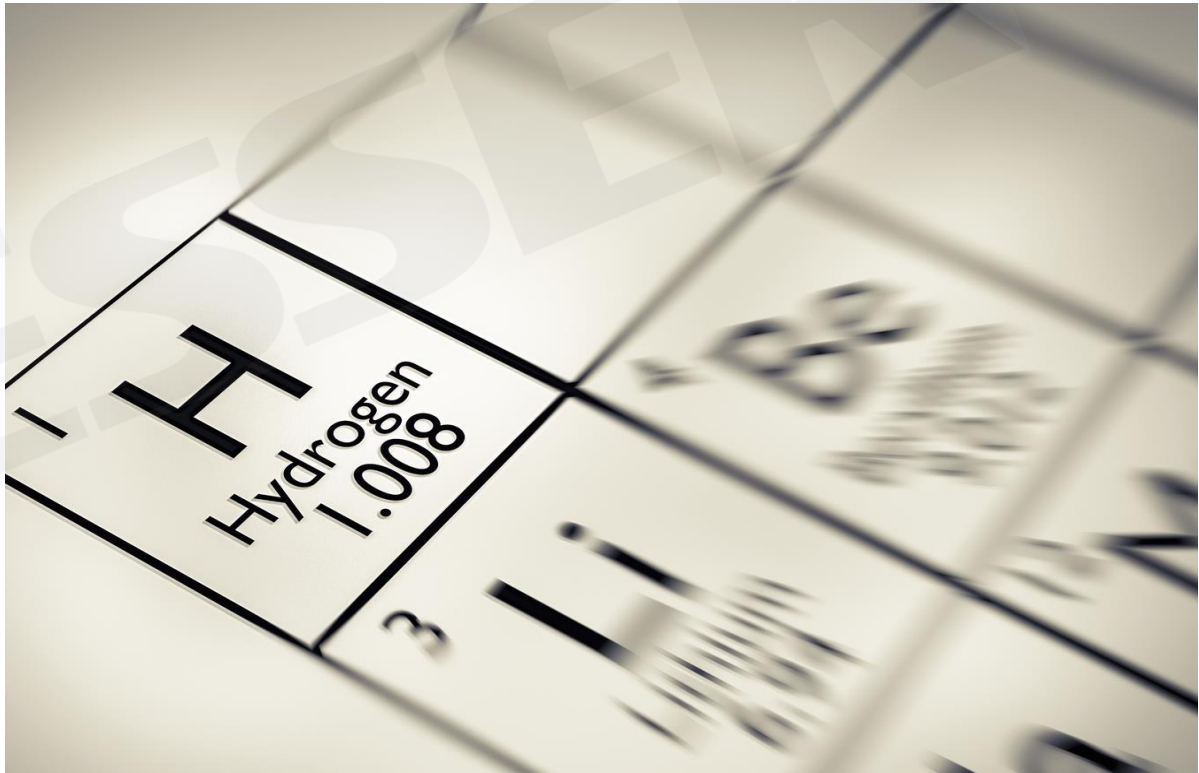
EPC by John Cockerill - Besix

NextGenerationEU and VLAIO subsidies
30 million EUR

Today – Conclusions

Key points

- Clean hydrogen will play an important role in decarbonising the EU, amongst other techniques
- Technology is available and ready to scale
- EU frameworks provide a solid foundation for green hydrogen deployment
- Need for robust support and funding. Crucial element for green hydrogen production and use (EU and member states)
- First movers are driving innovation. Early producers and offtakers can unlock market potential.
- Messer Belgium’s green H2 starts now !



Let’s connect

WE LOOK FORWARD TO WORKING WITH YOU

MESSER BELGIUM
NIEUWE WEG 1
2070 ZWIJNDRECHT
+32 (0)3 561 61 11
DIRK.DEKEULENAER@MESSERGROUP.COM